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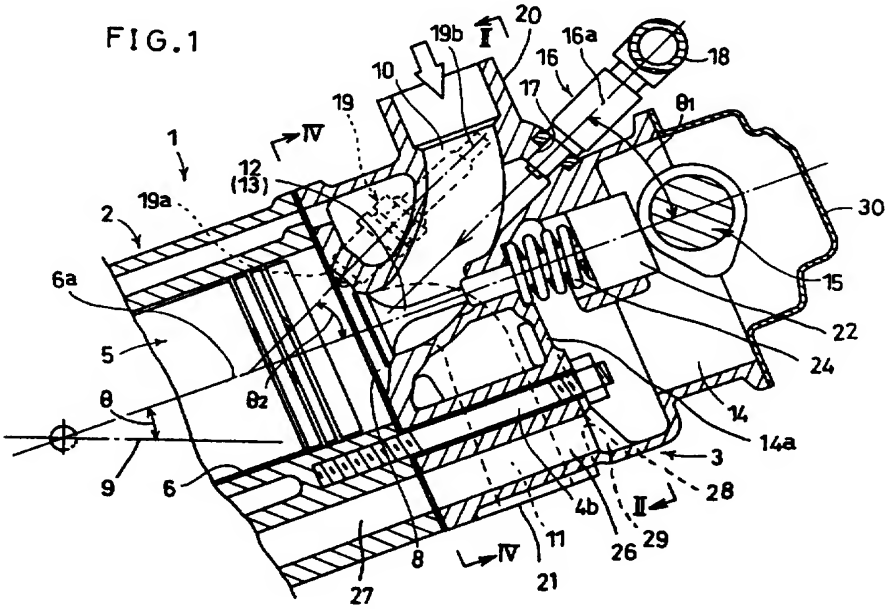
# (54) Spark-ignition i.c.engine

(57) In an engine with side-by-side cylinder head intake and exhaust valves 12, 13 and intake and exhaust ports 10 and 11 extending to opposite sides of the head, a fuel injector 16 and a spark plug 19 mounted on the intake port side of the head have their axes 16a and 19b inclined away from the exhaust port side relative to the cylinder axis 6a. The cylinders 6 may in use be inclined to the vertical, a trough 28 in the head 3 collecting oil for return to the sump through passages 26, 27 with the trough spaced from the boss 21 defining the downstream end of the exhaust port. The head 3 is secured to the block 2 by bolts (4a, Fig.2) passing outwardly of the valve gear chamber 14 and bolts 4b extending into the chamber.

FIG.1

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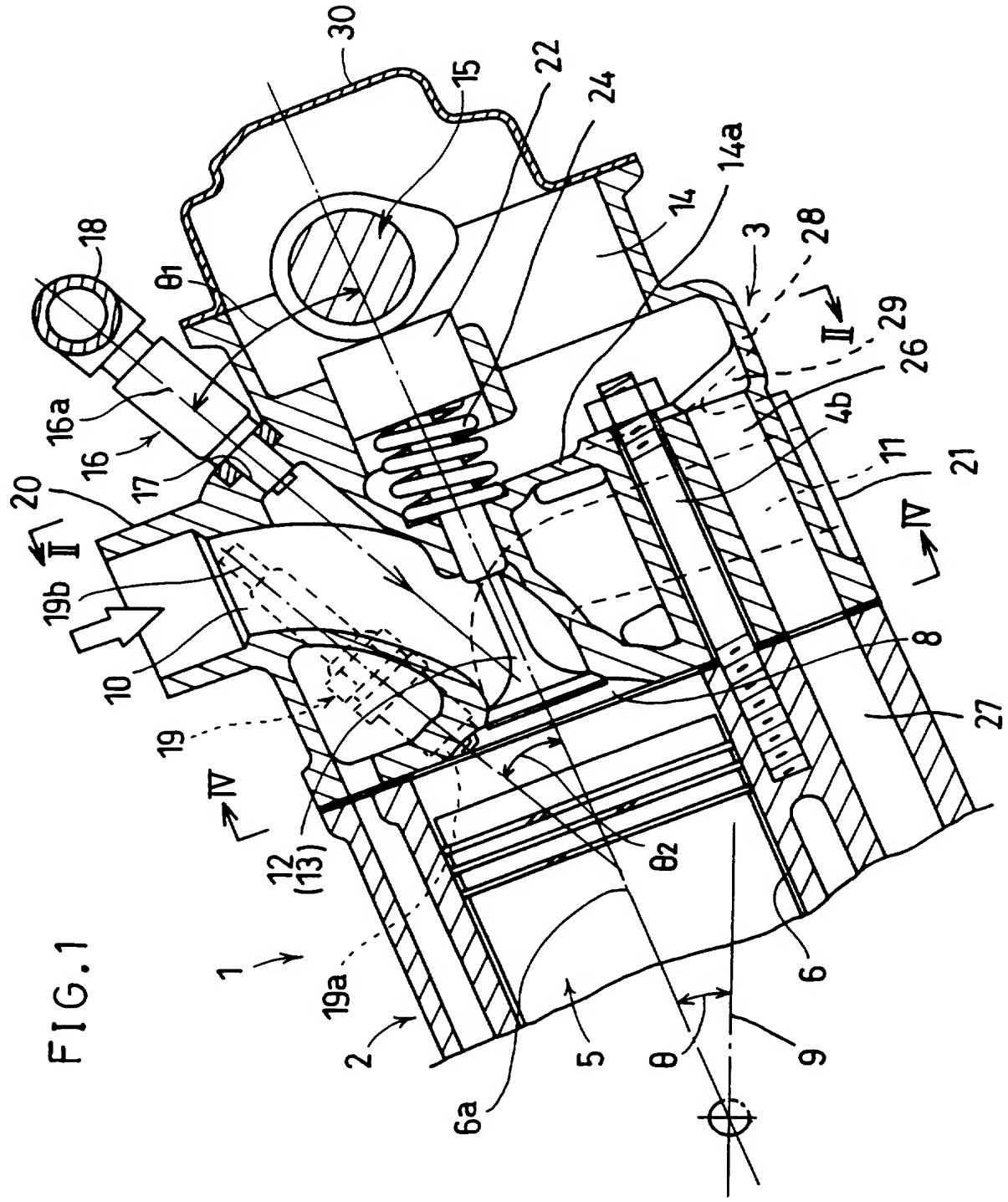
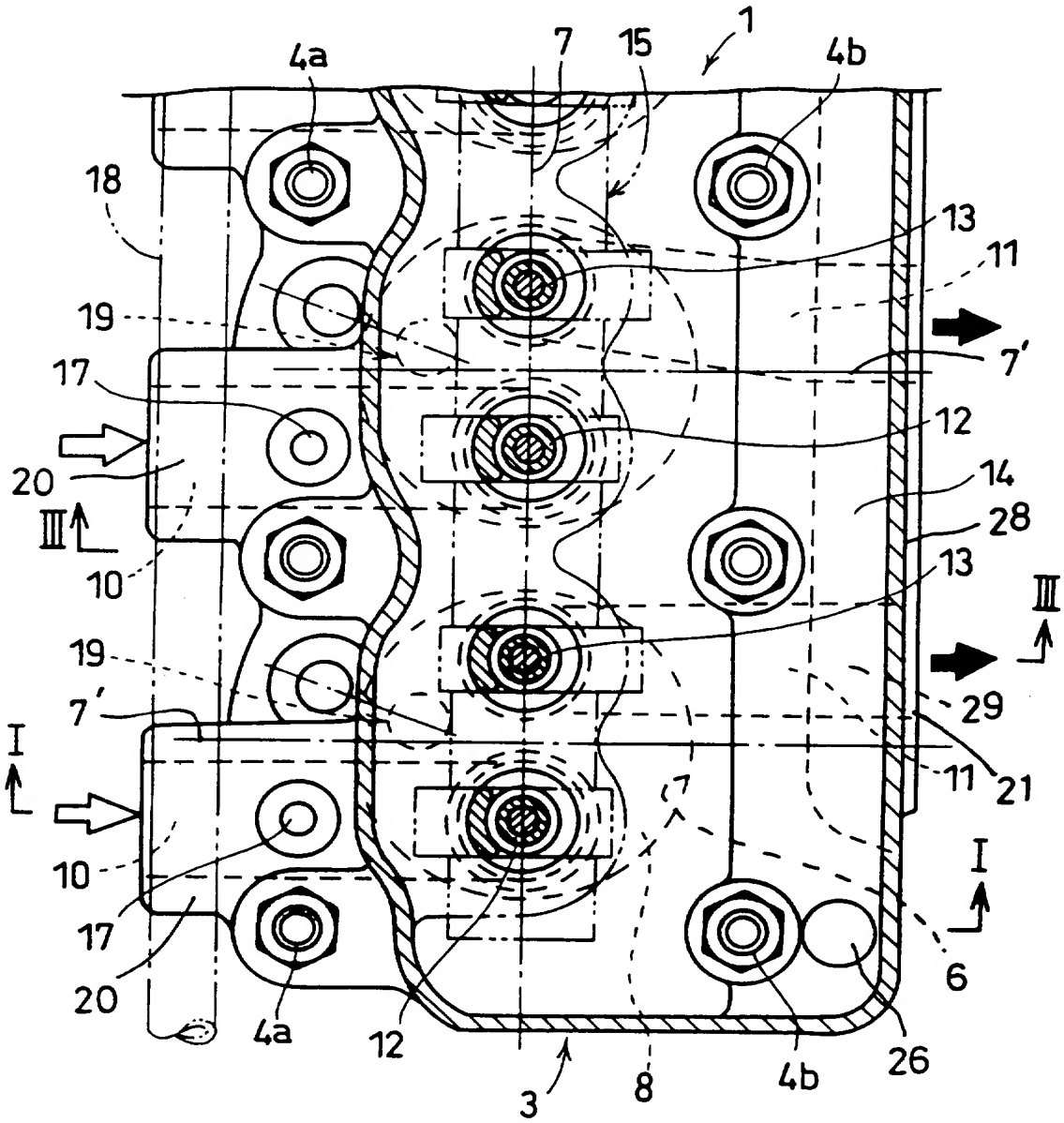
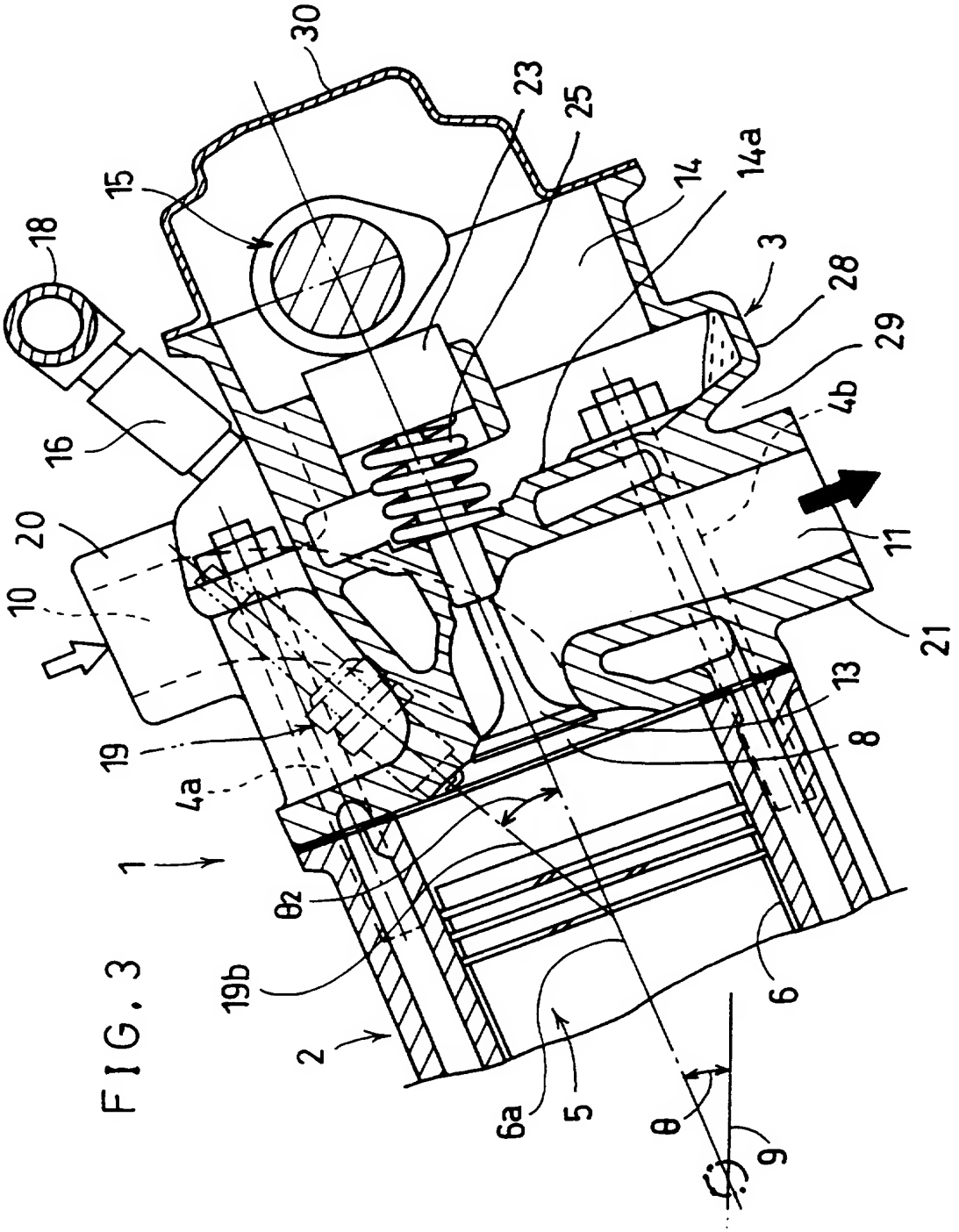

30
15
22
24
14a
14
3
28
18
θ1
29
II
26
16a
4b
16
17
11
21
20
IV
II
19b
8
10
27
19
IV
12
(13)
θ2
1
19a
6
2
5
θ
9
6a

FIG. 1

FIG. 2


1
4a
7
15
4b
18
13
11
19
7'
17
12
20
14
III
28
10
13
III
19
29
7'
I
11
21
10
I
17
6
20
4a
12
26
3
8
4b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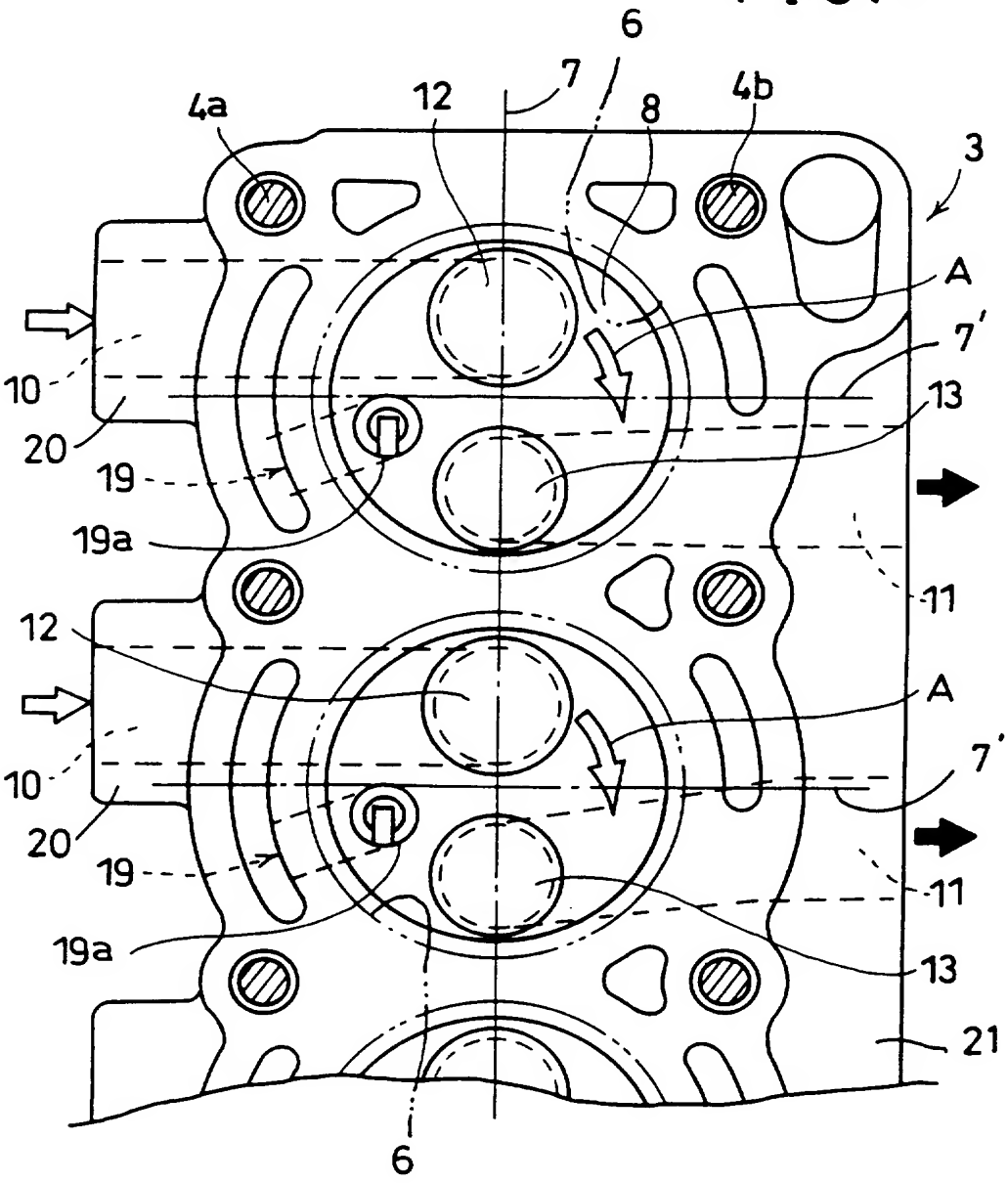
23
25
15
14
14a
18
3
28
29
16
4b
20
11
10
21
13
19
8
4a
1
θ2
19b
6
2
6a
5
θ
9

FIG. 3

FIG. 4



# A SPARK IGNITION INTERNAL COMBUSTION ENGINE

This invention relates generally to a spark ignition internal combustion engine. More specifically, the present invention relates to a spark ignition interna:l combustion engine of the type wherein a fuel injection valve is mounted on the cylinder head for injecting fuel into an inlet port.

A spark ignition internal combustion engine of the above-described type is disclosed in Japanese Utility Model Application Laid-open No. 3-63763 (Laid-open: June 21, 1991) or Japanese Utility Model Publication No. 5-3742 (Published: January 28, 1993) for example. Specifically, the engine disclosed in each of these Japanese documents mainly comprises a cylinder block having at least one cylinder with an axis, and a cylinder head mounted to the cylinder block to internally define a combustion chamber in corresponding relation to said at least one cylinder. The cylinder head has an inlet side formed with an inlet port which communicates with the combustion chamber and is provided with an inlet valve. The cylinder head also has an exhaust side formed with an exhaust port which communicates with the combustion chamber and is provided with an exhaust valve. The inlet valve and the exhaust valve are inclined relative to the cylinder axis in the opposite directions.

Further, the prior art engine also comprises a fuel injection valve mounted on the inlet side of the cylinder head for injecting fuel into the inlet port and a spark plug mounted on the cylinder head to face the combustion chamber. The fuel injection valve has an axis which is inclined away from the exhaust side relative to the cylinder axis by an angle greater than the inclination angle of the inlet valve.

According to the engine structure described above, the spark plug need be mounted on the exhaust side of the cylinder head for the following reason.

As described above, the inlet valve mounted on the inlet side of the cylinder head is inclined relative to the cylinder axis in a direction away from the exhaust side, and the fuel injection valve mounted on the inlet side of the cylinder head is also inclined relative to the cylinder axis in a similar direction but by a greater angle than the inclination angle of the inlet valve. Since the fuel injection valve need be connected to a fuel delivery pipe which extends in parallel to a center line which is parallel to the crankshaft between the inlet and exhaust sides of the cylinder head, the spark plug cannot be mounted on the inlet side of the cylinder head due to the hindering presence of the fuel delivery pipe.

On the other hand, when the spark plug is mounted on the exhaust side of the cylinder head, the fuel injected by the fuel injection valve together with air introduced through the inlet port immediately reaches the spark plug because the inlet port which is formed at the inlet side of the cylinder head is oriented toward the exhaust side. Thus, the spark plug may become wet with the injected fuel which reaches the spark plug before being sufficiently mixed with the simultaneously introduced air. The engine encounters difficulty in starting particularly at low temperature.

Further, as also described previously, both of the inlet and exhaust valves are inclined relative to the cylinder axis in the opposite direction with the fuel injection valve inclined even more sharply than the inlet valve. As a result, the cylinder head together with its associated

components becomes bulky which results in an overall size and weight increase of the engine. Besides, separate cam shafts need be provided for separately driving the inlet and exhaust valves.

Moreover, if the engine is mounted in an inclined or slanted posture as required for a cab-over-engine vehicle, the spark plug may be located on the lower side, which leads to difficulty in making access to the spark plug for removal and re-mounting thereof.

It is, therefore, an object of the present invention to provide a spark ignition internal combustion engine which can overcome the above-described problems.

According to the present invention, there is provided a spark ignition internal combustion engine comprising:

a cylinder block having at least one cylinder with an axis;

a cylinder head mounted to the cylinder block to internally define a combustion chamber in corresponding relation to said at least one cylinder, the cylinder head having an inlet side formed with an inlet port which communicates with the combustion chamber and which is provided with an inlet valve, the cylinder head also having an exhaust side formed with an exhaust port which communicates with the combustion chamber and which is provided with an exhaust valve;

a fuel injection valve mounted on the inlet side of the cylinder head for injecting fuel into the inlet port, the fuel injection valve having an axis which is inclined away from the exhaust side relative to the cylinder axis; and

a spark plug mounted on the cylinder head to face the combustion chamber; characterised:

in that the inlet and exhaust valves are disposed side-by-side generally on a center line which is parallel to a crankshaft between the inlet and exhaust sides of the cylinder head;

in that the inlet valve extends substantially parallel to the cylinder axis; and

in that the spark plug is mounted on the inlet side of the cylinder head and inclined away from the outlet side relative to the cylinder axis.

According to the arrangement described above, the fuel injected by the fuel injection valve together with the air supplied through the inlet port is made to flow along the circumference of the combustion chamber past the exhaust valve before reaching the spark plug. Thus, the injected fuel moves along a longest possible path before reaching the spark plug. As a result, the injected fuel can be well mixed with the supplied air before ignition, and the spark plug is prevented from being wet with the fuel which would otherwise flow along a shortcut path within the combustion chamber. Further, since the inlet valve is made to extend substantially in parallel to the cylinder axis, the inclination angle of the fuel injection valve can be rendered relatively small, thereby enabling reduction of the overall size of the engine 1 including the fuel delivery pipe .

Preferably, the exhaust valve may also extend substantially parallel to the cylinder axis. In this case, the inlet and exhaust valves can be driven by a common cam shaft, thereby contributing to an additional size and weight reduction of the engine.

Further, the cylinder block may be inclined so that one of the inlet and exhaust sides of the cylinder head is positioned above the other. Such an arrangement makes it

possible to mount the engine in a cab-over-engine vehicle. In this case, it is preferable that the inclination of the cylinder block is such that the inlet side of the cylinder head is positioned above the exhaust side, thereby improving access to the spark plug.

According to a preferred embodiment of the present invention, the cylinder head is fixed to the cylinder block by a first group of bolts on the inlet side of the cylinder head as well as by a second group of bolts on the exhaust side of the cylinder head, and the first group of bolts is disposed outside a valve drive housing which is provided on the cylinder head on a side thereof opposite to the cylinder block. Due to such a design, the fuel injection valve can be located as close to the cylinder axis as possible to further reduce the size and weight of the engine. Moreover, the valve drive housing may be provided with an oil trough adjoining a boss portion of the cylinder head in which the exhaust port extends, and an air gap is formed between the oil trough and the boss portion to prevent the lubricating oil from being deteriorated by the heat of the exhaust gas.

The present invention will be better understood by referring to the following detailed description of a preferred embodiment given with reference to the accompanying drawings.

In the accompanying drawings:

Fig. 1 is a view, in vertical section, showing an spark ignition internal combustion engine according to an embodiment of the present invention;

Fig. 2 is a sectional view of the same engine taken along lines II-II in Fig. 1, Fig. 2 also indicating section lines I-I taken for Fig. 1;

Fig. 3 is a sectional view of the same engine taken along lines III-III in Fig. 2; and

Fig. 4 is a sectional view of the same engine taken along lines IV-IV in Fig. 1.

A preferred embodiment of the present invention is now described below with reference to Figs. 1 to 4 of the accompanying drawings. Illustrated in these figures is a multi-cylinder internal combustion engine 1 which is designed for mounting in a cab-over-engine vehicle.

The engine 1 comprises a cylinder block 2 and a cylinder head 3 fixed to the upper end of the cylinder block 2 by means of a first group of bolts 4a at one side of the block 2 and a second group of bolts 4b at the other side. The cylinder block has a plurality of cylinders 6 arranged in an array along a longitudinal center line 7 of the cylinder head 3 which is parallel to the crankshaft (not shown), and a piston 5 slidably reciprocates in each of the cylinders 6. The cylinder head 3 is formed with a concave combustion chamber 8 facing each of the cylinders 6. As previously described, the engine 1 is designed for mounting on a cab-over-engine vehicle. Thus, each of the cylinders 6 is made to have an axis 6a which is inclined relative to a horizontal plane 9 by a suitable angle $\theta$.

The interior of the cylinder head 3 is provided with an inlet port 10 at one side of the head above the cylinder axis 6a for introducing air into each of the cylinders 6 together with a supplied amount of fuel. Further, the cylinder head 3 is provided internally with an exhaust port 11 at the other side of the head above the cylinder axis 6a for discharging the exhaust gas from each of the cylinders 6.

As shown in Figs. 2 and 4, the inlet port 10 has an inner end or opening located generally on the longitudinal center line 7 of the cylinder head 3 but offset in one direction from a transverse center line 7′ of the corresponding cylinder 6 which is perpendicular to the longitudinal center line 7 and the cylinder axis 6a. An inlet valve 12 is provided at the inner opening of the inlet port 10 with its valve stem extending substantially in parallel to the cylinder axis 6a.

Similarly, the exhaust port 11 has an inner end or opening located generally on the longitudinal center line 7 of the cylinder head 3 but offset from the transverse center line 7′ of the cylinder 6 in a direction opposite to the inner opening of the inlet port 10. Further, an exhaust valve 13 is provided at the inner opening of the exhaust port 11 with its valve stem extending substantially in parallel to the cylinder axis 6a.

According to the illustrated embodiment, the inner opening of the inlet port 10 is located to have its center exactly on the longitudinal center line 7 of the cylinder head 3. However, the center of the inner opening of the inlet port 10 may slightly deviate from the longitudinal center line 7 as long as the inner opening partially overlaps the longitudinal center line 7. Such is also applicable to the inner opening of the exhaust port 11.

As shown in Figs. 1 and 3, the inlet port 10 has an outer end formed in a first lateral boss portion 20 formed integrally with the cylinder head 3. Similarly, the exhaust port 11 has an outer end formed in a second lateral boss portion 21 formed integrally with the cylinder head 3.

The cylinder head 3 also has an integral valve drive housing 14 for accommodating a valve drive mechanism which comprises a cam shaft 15, valve lifters 22, 23 connected to the respective valves 12, 13, and springs 24, 25 for urging the valves lifters 22, 23 against the unnumbered cams carried by the cam shaft 15. As is conventionally known, lubricating oil is supplied for example via the bearing system (not shown) for the cam shaft 15 from the lower oil pan (not shown).

As shown in Fig. 1, the cylinder head 3 is additionally formed with an oil sink port 26 which opens at the bottom wall 14a of the valve drive housing 14 and is connected to an oil return channel 27 for returning the lubricating oil to the unillustrated oil pan. The valve drive housing 14 is integrally formed with an oil trough 28 extending adjacent to the bottom wall 14a for guiding the oil into the oil sink port 26. As shown in Figs. 2 and 3, the oil trough 28 is preferably spaced from the second boss portion 21 by an intervening air gap 29.

A fuel injection valve 16 is fitted in a mounting bore 17 of the cylinder head 3 near each of the first boss portions 20 for injecting fuel into the inlet port 10. As shown in Fig. 1, the fuel injection valve 16 has an injection axis 16a which is inclined away from the exhaust port 11 by a suitable angle $\theta$ 1 relative to the cylinder axis 6a, so that the injected fuel is directed toward the inner opening of the inlet port 10. The fuel injection valve 16 is connected to a fuel delivery pipe 18 extending in parallel to the longitudinal center line 7 of the cylinder block 3 (see Fig. 2).

A spark plug 19 for each of the cylinders 6 is removably mounted on the cylinder head 3. The plug 19 has an electrode portion 19a facing the combustion chamber 8 at

a position offset from the longitudinal center line 7 of the cylinder head 3 toward the outer opening of the inlet port 10, as clearly shown in Fig. 4. Further, the plug 19 has an axis 19b which is inclined away from the exhaust port 11 by a suitable angle θ 2 relative to the cylinder axis 6a, as shown in Figs. 1 and 3. The inclination angle θ 2 of the plug axis 19b may be equal to or slightly different from the inclination angle θ 1 of the injection axis 16a of the fuel injection valve 16.

A head cover 30 is attached to the cylinder head 3 to close the valve drive housing 14.

According to the arrangement described above, the inlet and exhaust ports 10, 11 have their respective inner openings located generally on the longitudinal center line 7 of the cylinder head 3 and spaced therealong, and the spark plug 19 is made to face the combustion chamber 8 at a position offset from the longitudinal center line 7 of the cylinder head 3 toward the outer opening of the inlet port 10. Therefore, the fuel injected by the fuel injection valve 12 together with the air supplied through the inlet port 10 flows along the circumference of the combustion chamber 8 past the exhaust valve before reaching the electrode portion 19a of the spark plug 19, as indicated by arrow A in Fig. 4. In other words, the injected fuel is made to flow along a longest possible path before reaching the spark plug 19. As a result, the injected fuel can be well mixed with the supplied air before ignition, and the spark plug 19 is prevented from being wet with the fuel which would otherwise flow along a shortcut path within the combustion chamber 8.

As previously described, the inlet valve 12 is made to extend substantially in parallel to the cylinder axis 6a. As a result, the inclination angle θ 1 of the fuel

injection valve 16 can be rendered relatively small, thereby enabling reduction of the overall size of the engine 1 including the fuel delivery pipe 18.

According to the illustrated embodiment, further, the exhaust valve 13 is also made to extend substantially in parallel to the longitudinal center line 7 of the cylinder head 3. Thus, the single cam shaft 15 can be made to equally act on both of the inlet and exhaust valves 12, 13, consequently leading to an additional size reduction of the engine 1 by obviating the need for providing separate cam shafts and related components for the respective valves 12, 13.

Further, due to a reduction in the inclination angle $\theta$ 1 of the fuel injection valve 16, the spark plug 19 can be mounted on the same side as the fuel injection valve 16 and similarly inclined relative to the cylinder axis 6a in a direction away from the exhaust port 11. Thus, mounting and removal of the spark plug 19 can be performed without interfering with the fuel delivery pipe 18.

Further, according to the illustrated embodiment, the air gap 29 between the second boss portion 21 and the oil trough 28 reduces heat transmission between these two components while also allowing ambient air to cool the lubricating oil temporarily trapped in the trough 28. As a result, the lubricating oil is prevented or restrained from being deteriorated by the heat of the exhaust gas before returning to the oil pan (not shown) through the oil sink 26 and the return passage 27.

As shown in Figs. 2 and 3, the first group of bolts 4a used for fixing the cylinder head 3 to the cylinder block 2 is located outside the valve drive housing 14 at one

side of the cylinder head 3. As a result, the fuel injection valve 16 can be positioned as close to the cylinder axis 6a as possible, thereby further contributing to the size and weight reduction of the engine 1.

The preferred embodiment described above is given only by way of example and not limitative of the scope of the present invention. For instance, the cylinder block 2 may be arranged upright depending on the type of vehicle and/or the designer 20 preference.

CLAIMS:

1. A spark ignition internal combustion engine comprising:

a cylinder block having at least one cylinder with an axis;

a cylinder head mounted to the cylinder block to internally define a combustion chamber in corresponding relation to said at least one cylinder, the cylinder head having an inlet side formed with an inlet port which communicates with the combustion chamber and which is provided with an inlet valve, the cylinder head also having an exhaust side formed with an exhaust port which communicates with the combustion chamber and which is provided with an exhaust valve;

a fuel injection valve mounted on the inlet side of the cylinder head for injecting fuel into the inlet port, the fuel injection valve having an axis which is inclined away from the exhaust side relative to the cylinder axis; and

a spark plug mounted on the cylinder head to face the combustion chamber; characterised:

in that the inlet and exhaust valves are disposed side-by-side generally on a center line which is parallel to a crankshaft between the inlet and exhaust sides of the cylinder head;

in that the inlet valve extends substantially parallel to the cylinder axis; and

in that the spark plug is mounted on the inlet side of the cylinder head and inclined away from the outlet side relative to the cylinder axis.

2. The engine according to claim 1, wherein the exhaust valve also extends substantially parallel to the cylinder axis.

3. The engine according to claim 2, wherein the inlet and exhaust valves are driven by a common cam shaft.

4. The engine according to any one of claims 1 to 3, wherein the cylinder block is inclined so that the inlet side of the cylinder head is positioned above the exhaust side.

5. The engine according to any one of claims 1 to 4, wherein the cylinder head is fixed to the cylinder block by a first group of bolts on the inlet side of the cylinder head as well as by a second group of bolts on the exhaust side of the cylinder head, the first group of bolts being disposed outside a valve drive housing which is provided on the cylinder head on a side thereof opposite to the cylinder block.

6. The engine according to any one of claims 1 to 5, wherein the cylinder head is provided with a valve drive housing on a side opposite to the cylinder block , the valve drive housing being provided with an oil trough adjoining a boss portion of the cylinder head in which the exhaust port extends, an air gap being formed between the oil trough and the boss portion.

7. A spark ignition internal combustion engine substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

| Patents Act 1977<br>Examiner's report to the Comptroller under Section 17<br>(The Search report) | Application number<br>GB 9525500.6 |
|---|---|
| **Relevant Technical Fields**<br>(i) UK Cl (Ed.O) F1B<br>(ii) Int Cl (Ed.6) F02B 23/08, 23/10 F02M 69/04 | Search Examiner<br>R J DENNIS<br>Date of completion of Search<br>12 FEBRUARY 1996 |
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